# REPORT DOCUMENTATION PAGE

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**14. ABSTRACT**

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MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO) 22 May 2002

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2002-130**
C.T. Liu (PRSM); F.P. Chiang (NYSU), "Investigating the Deformation and Failure Mechanisms in Bi-Material Systems Under Tension"

**ASME Winter Meeting** **(Statement A)**
**(Blacksburg, VA, 24-28 June 2002)** **(Deadline = 23 June 2002)**

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PHILIP A. KESSEL Date
Technical Advisor
Space and Missile Propulsion Division

# Investigating the Deformation and Failure Mechanisms in Bi-Material Systems under Tension

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# Objectives

¥ Investigate the Local Strain Distribution and Failure Mode in a Bi-Material Bonded

—Specimens under a Constant Displacement Rate Condition.

* Displacement Rate = 0.02 in/min

¥ Determine the Critical Strain for Debond at the Interface between the Two Materials.

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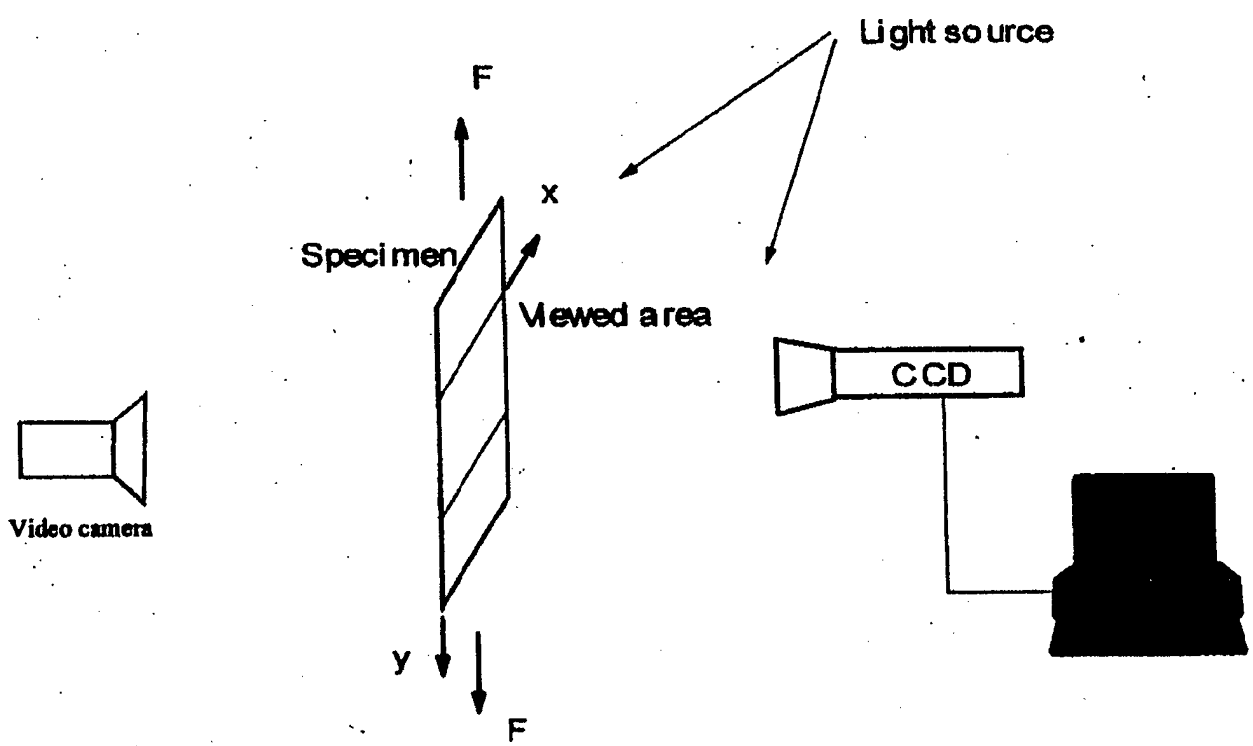
# Experimental Set-Up



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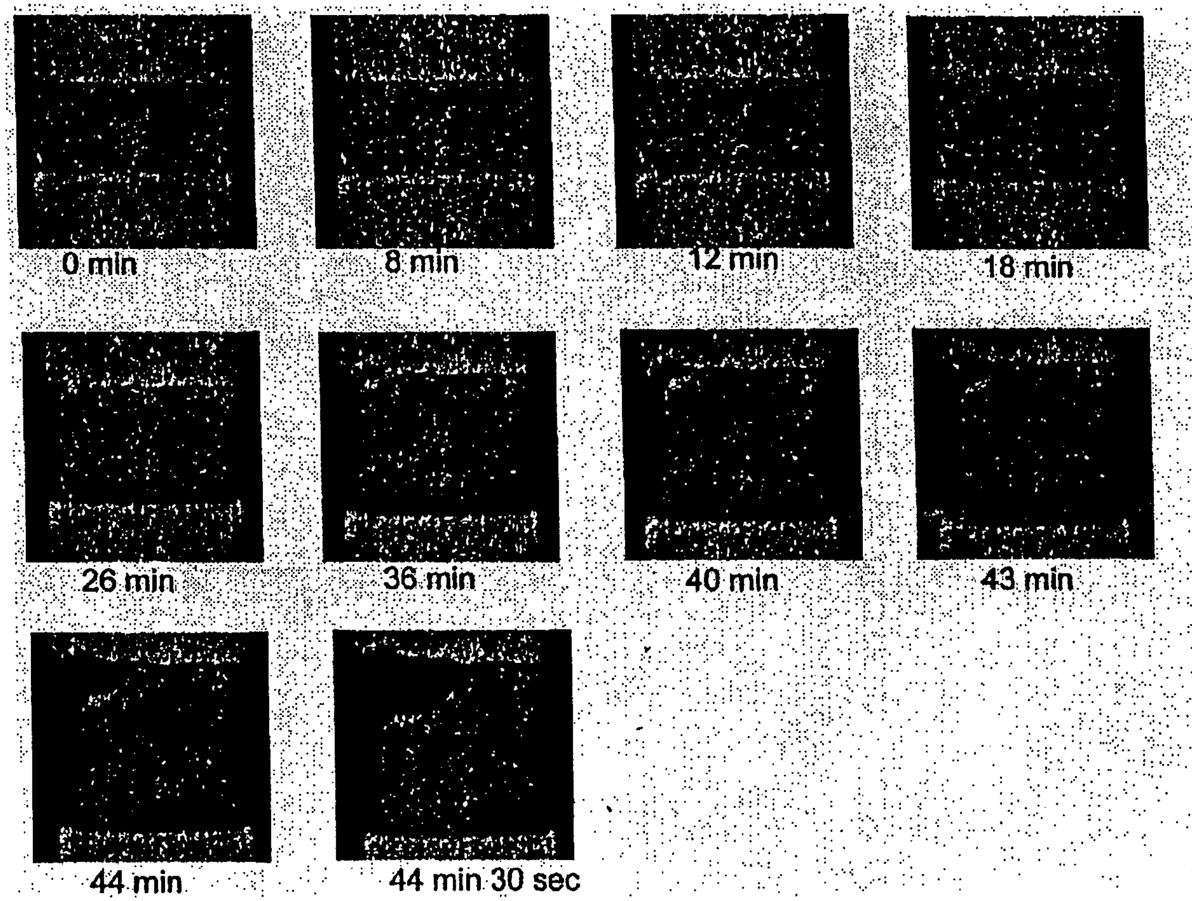
# The Mechanism of Debonding

## Thickness to Width Ratio: 1:1:00



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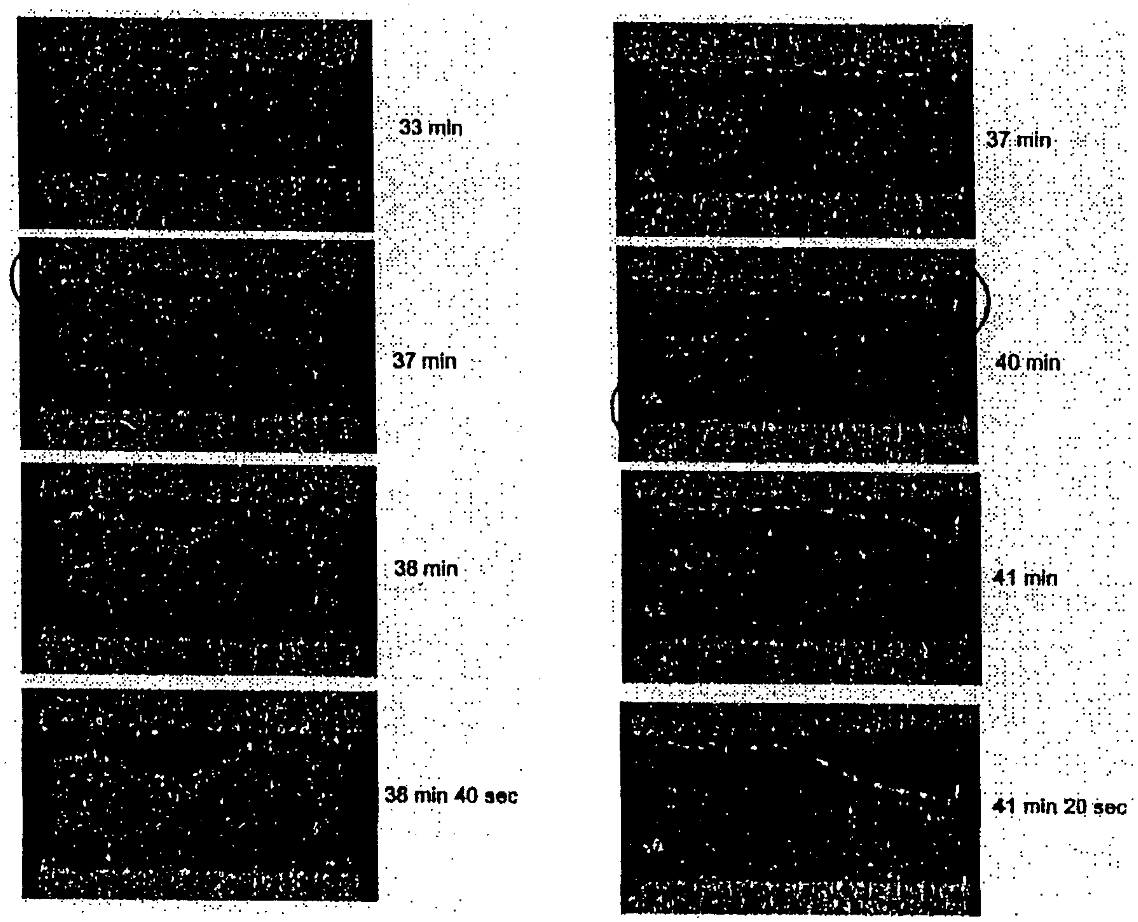
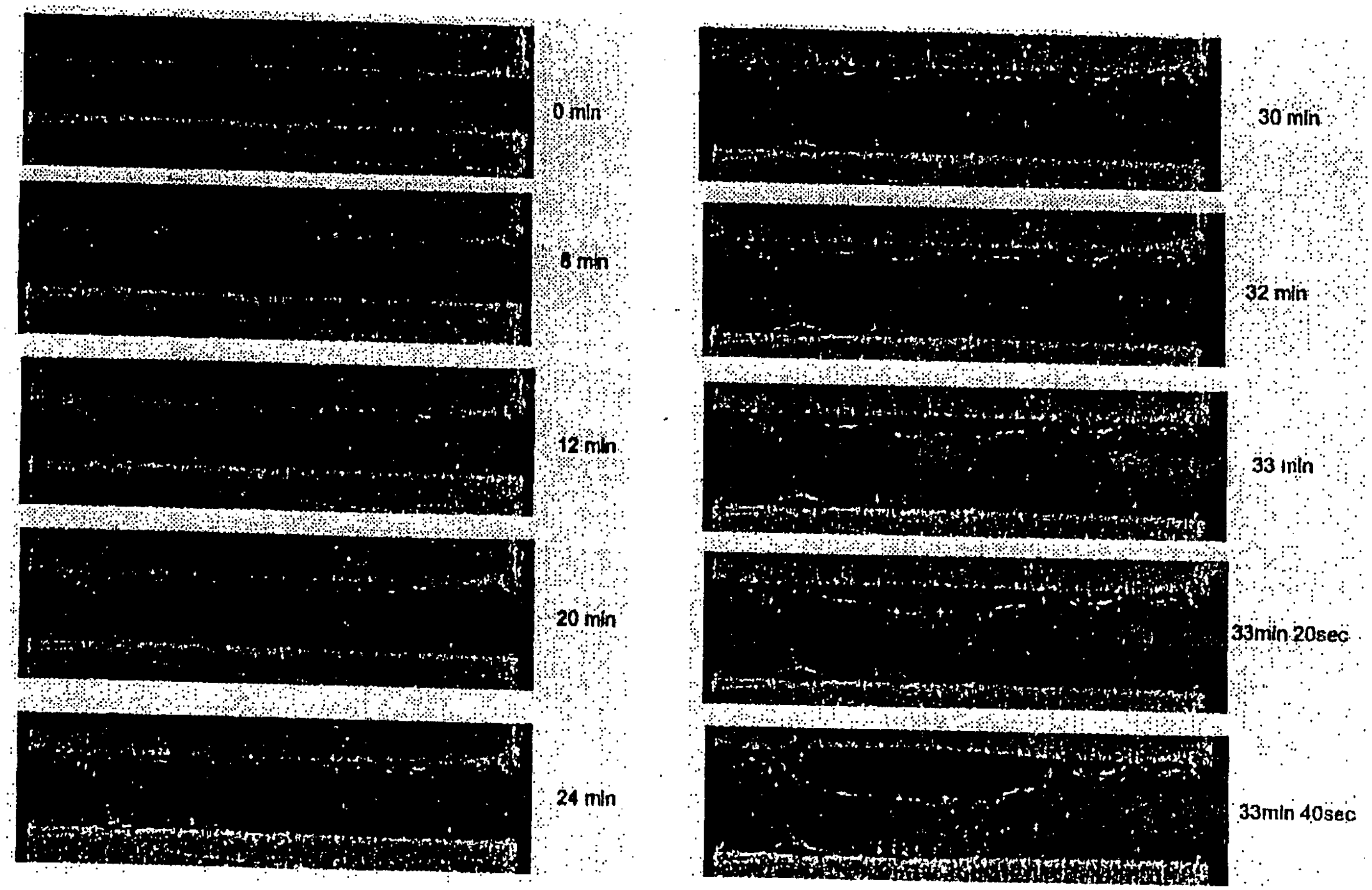
# The Mechanism of Debonding

## Thickness to Width Ratio: 1:2.25



# The Mechanism of Debonding

## Thickness to Width Ratio: 1:5.00



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# The Debonding Modes

H ~ 4 in
h ~ 0.1 in

| Size: t x w (in) | Ratio: t:w | Number of Specimens | Debond at center | Debond at corner |
|---|---|---|---|---|
| 0.2 x 1 | 1:5 | 2 | 2 | 0 |
| 0.2 x 0.5 | 1:2.5 | 3 | 3 | 0 |
| 0.2 x 0.4 | 1:2 | 4 | 1 | 3 |
| 0.2 x 0.2 | 1:1 | 2 | 0 | 2 |

Critical ratio: ~ 1:2.25; either mode may prevail

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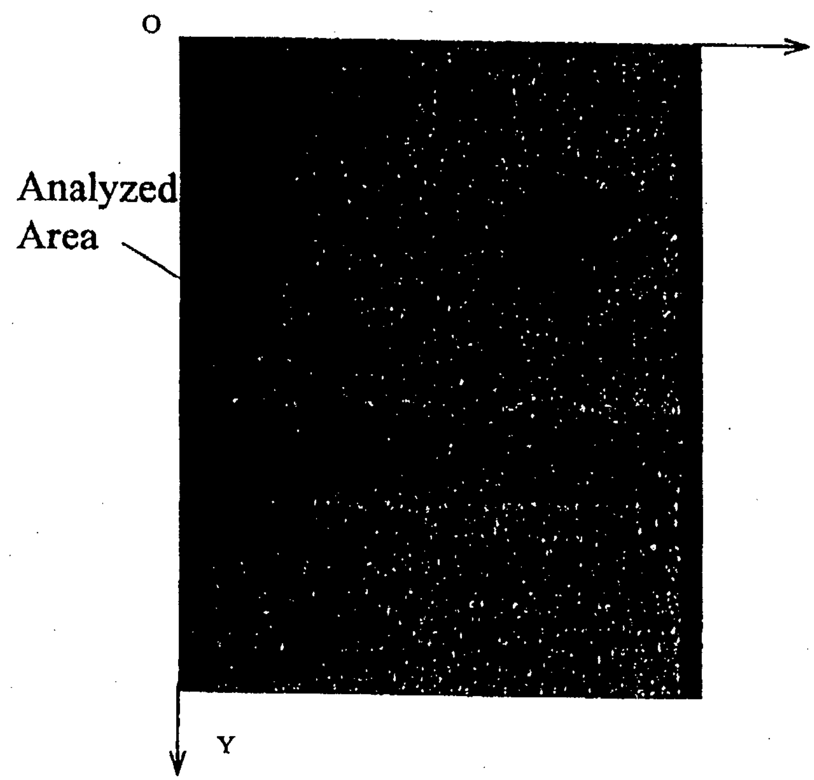
# Analysis of Deformation



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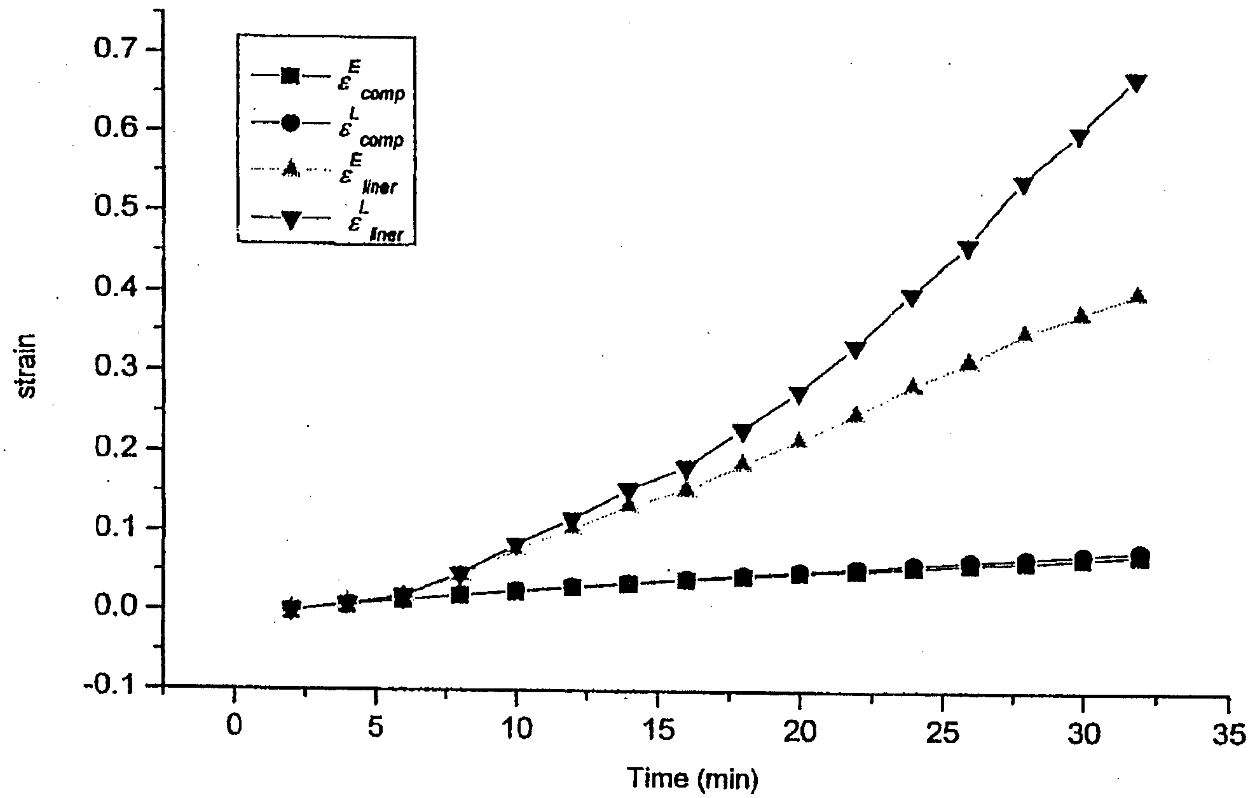
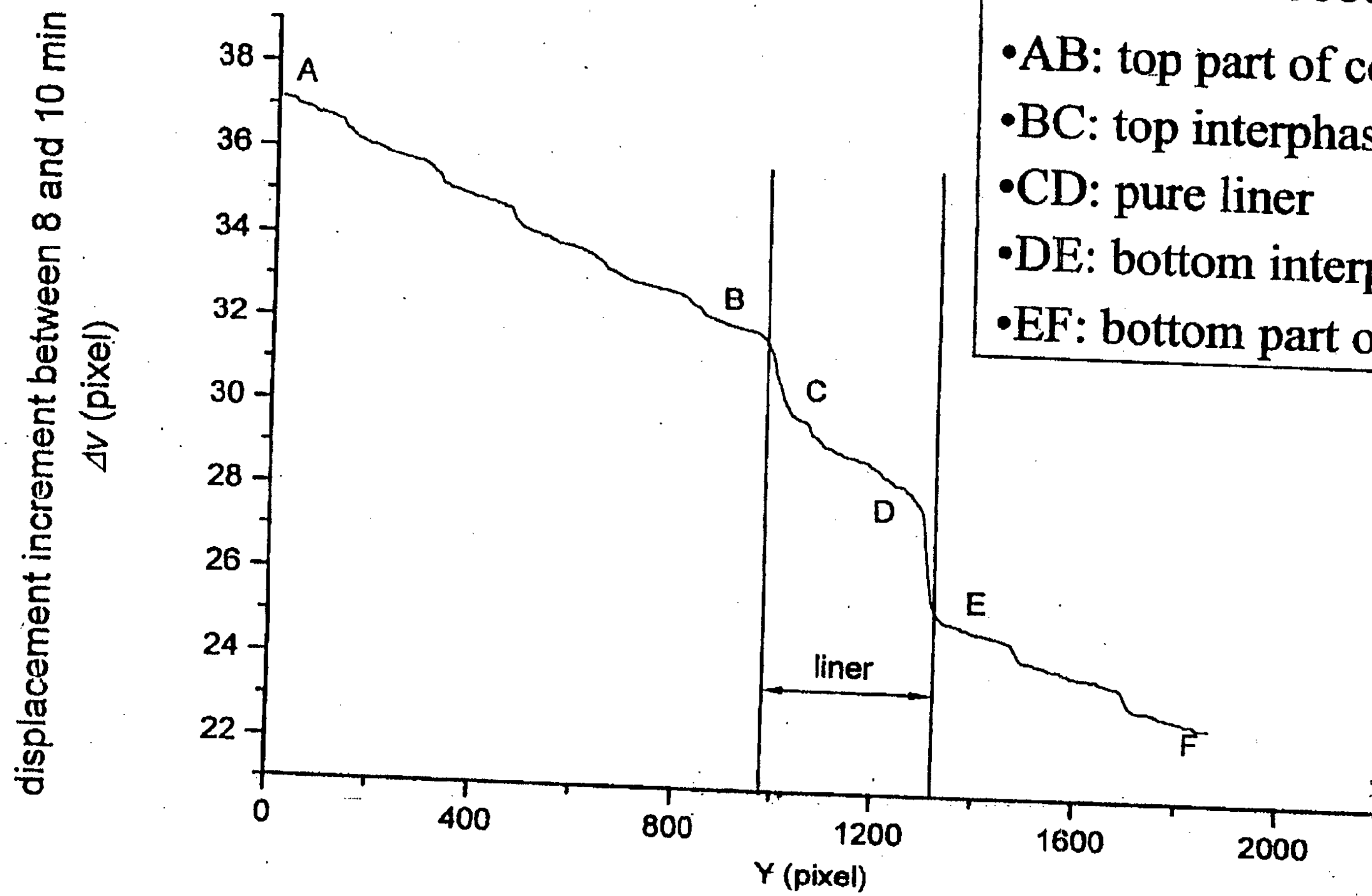
# Average Strain Versus Force Curves

## Thickness to Width Ratio: 1:5.00



# Displacement Increment Distribution along y Direction

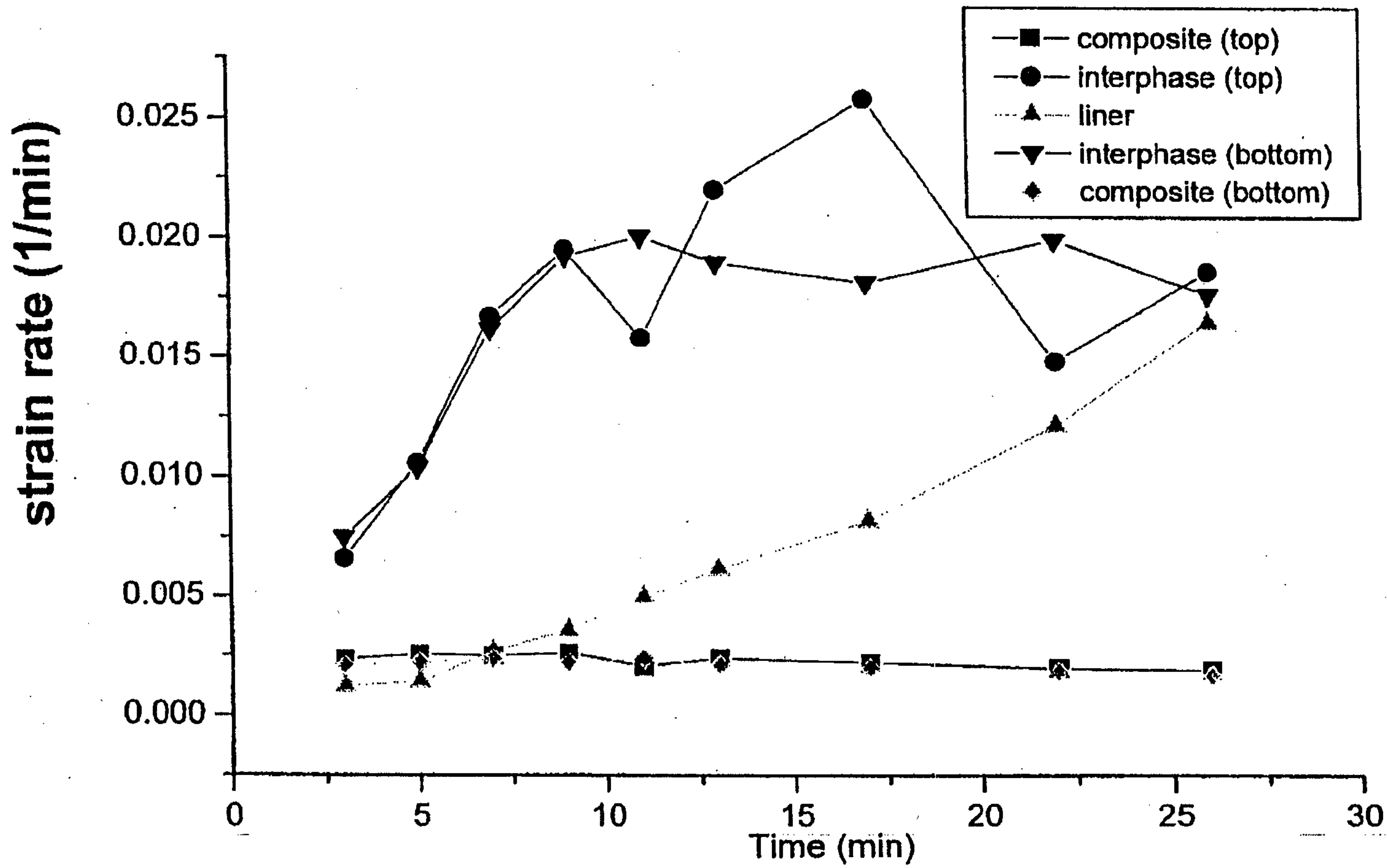



Five linear sections:

- AB: top part of composite
- BC: top interphase
- CD: pure liner
- DE: bottom interphase
- EF: bottom part of composite

# Strain Rate versus Time Curves

## Thickness to Width Ratio: 1:2.25



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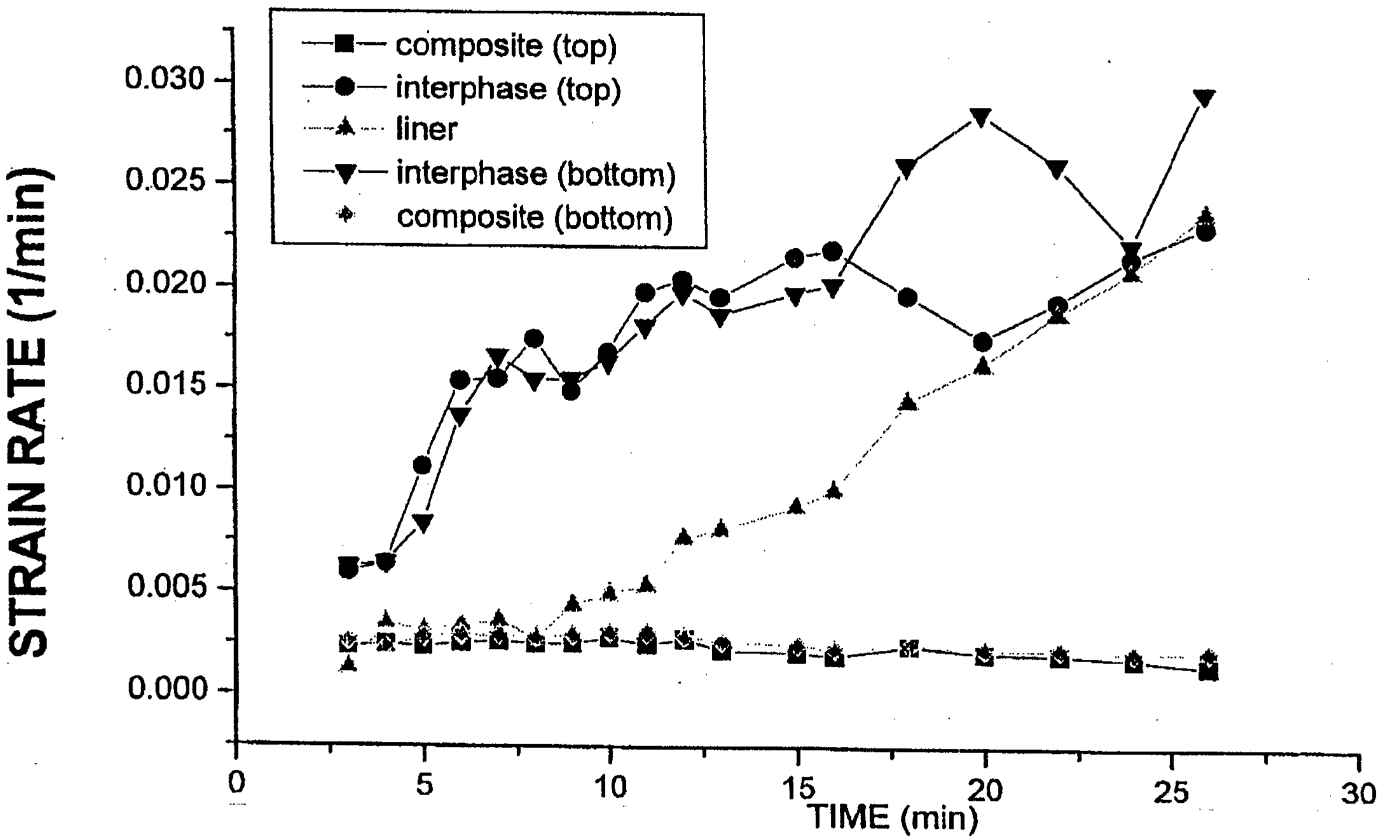
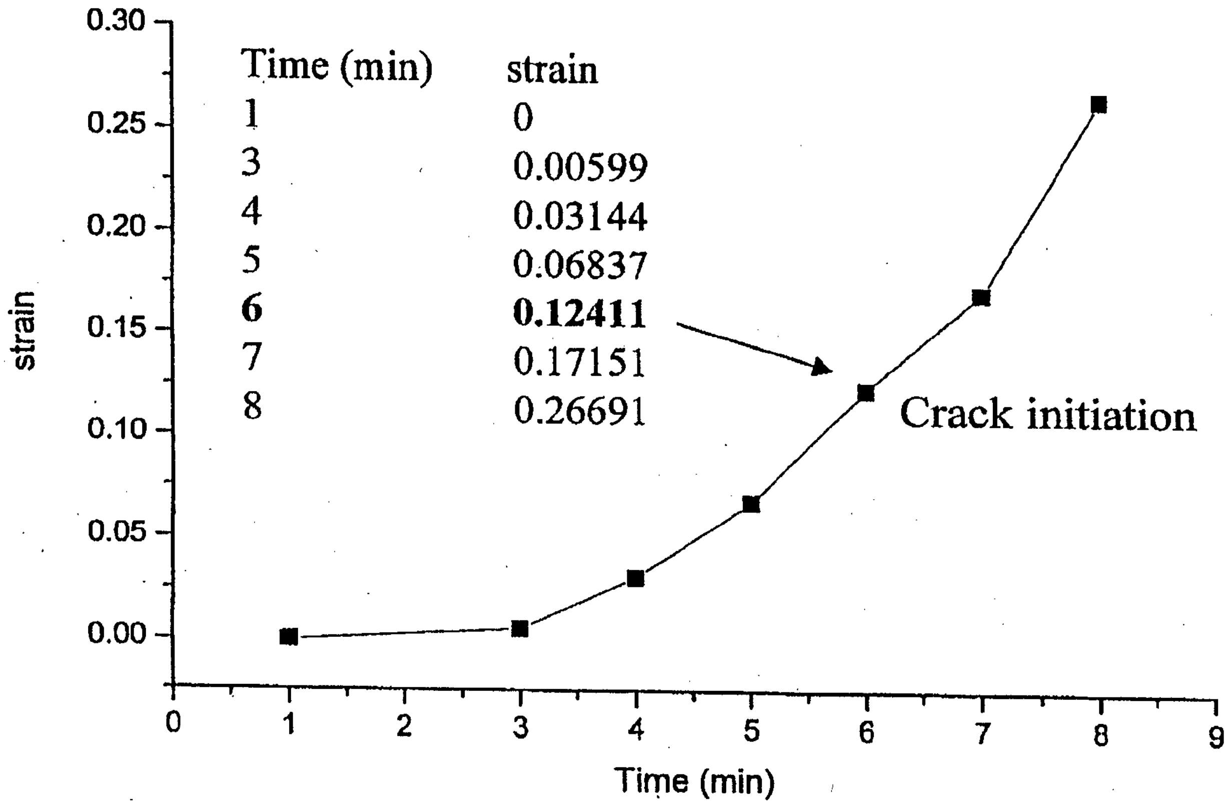
# Strain Rate versus Time Curves

## Thickness to Width Ratio: 1:5.00



# The Time History of Local Strain near Interface




| Time (min) | strain |
|---|---|
| 1 | 0 |
| 3 | 0.00599 |
| 4 | 0.03144 |
| 5 | 0.06837 |
| **6** | **0.12411** |
| 7 | 0.17151 |
| 8 | 0.26691 |

# Summary of Debonding Initiation Strain

| Specimen # | Size: t x w (in) | Ratio: t:w | Crack initiation strain |
|---|---|---|---|
| k | 0.2 x 1 | 1:5 | 0.12 |
| n | 0.2 x 0.5 | 1:2.5 | 0.14 |
| w | 0.2 x 0.45 | 1:2.25 | 0.13 |
| o | 0.2 x 0.2 | 1:1 | 0.13 |

# Conclusions

¥ The Failure location depends on the geometry of the specimen.

¥ There are interphase regions near the interfaces of the specimen.

¥ The strain rates in the rubber layer and the interface region change with time.

¥ The strain rate in the interphase region is significant ly higher than that in the rubber and the composite layers.

¥ The average critical local debond strain is 13%, which is independent of specimen geometry.